

COLUMBIAN UNIVERSITY

TO ALL WHOM IT MAY CONCERN:

APPARATUS USING IN-BAND TYPE ACCESS SYSTEM

of which the following is a specification : -

APPARATUS USING IN-BAND TYPE ACCESS SYSTEM

5 1. Field of the Invention

2. Description of the Related Art

In an STM (SONET/SDH) transmission system, the management means or method is realized by using an overhead provided separately from a user data field (payload) in a transmission frame. In the overhead, two independent data communication channels are defined. More particularly, the above two independent data communication channels are respectively a section DCC (192 kbps) and a line DCC (576 kbps) where DCC is an abbreviation of Data Communication Channel. A data packet having a control information field is transmitted via the data communication channels. In the control information field, headers in the respective hierarchical levels based on the information switch

In an ATM (Asynchronous Transfer Mode) transmission system, a capability of transmitting data via the above-mentioned data communication channels is defined when loaded with the payload. More particularly, such a payload created in an STM(SONET/SDH) system (SONET: Synchronous Optical Network/Synchronous Digital Hierarchy) is used as a carrier. A fundamental operation/function in which a cell is placed in a logical transmission path/channel dynamically (or statically) set is monitored based on ATM switch information with which switch intelligence parts of the respective apparatuses are linked via meta channels.

The LAN-system CLAD units provided in the ATM system which are linked together (as starting
35 points of cell generation and ending points of cell termination) to transport cells by using the logical paths/channels set between the CLAD units view the

Originally, a site manager is defined in the management system of the LAN facility. An SNMP (Simple Network Management Protocol) application is utilized in the site manager. Management information collection and delivery by SNMP packets that are created and terminated by the SNMP application is replaced by an ILMI (Integrated/Interim Local Management Interface) which is defined on the virtual facility via which the LAN-system CLAD units are linked.

In order to correlate the site manager with the resource information of the CLAD units themselves that connote the ATM transmission, it is required to provide SNMP-based information understandable by the site manager from the apparatus equipped with the CLAD unit, irrespective of whether the ATM transmission is connoted.

30 Conventionally, each of the apparatuses
equipped with the CLAD units respectively provides,
via a system separate from the system involved in
transmission of the SNMP information concerning the
ATM transmission, the site manager with the SNMP
35 information concerning data transmission. The above
separate system is a dedicated or leased
communication line. Thus, the CLAD units are added

5 external interface serves as a cross point with the customer network management agent process other than the resource management information path set on the PVC logically set traffic defined by the ATM switch.

The transmission apparatus may further comprise an interface via which the resource management information can be sent to a transaction language (TL1) which performs a facility node resource management in an STM transmission and a common management information service element and can further be sent to the customer network management agent process and the user network management system.

The above objects of the present invention are also achieved by a transmission apparatus comprising: an ATM/user network interface which makes a contact point with a user network management system which handles resource management information concerning a cell assembly and disassembly unit which is accommodated outside of the transmission apparatus as an external unit; a LAN interface which makes a contact point with another user network management system which handles resource management information concerning another cell assembly and

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Other objects, features and advantages of the present invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings, in which:

Fig. 2 is a diagram for illustrating an
15 access to a customer network management agent
process from a network management system of each
user, and a protocol stack utilized in the above
process according to an embodiment of the present
invention;

Fig. 4 schematically shows an example of a configuration of a transmission apparatus which functions as a network element according to the embodiment of the present invention;

30 Fig. 6 is a diagram of a hardware
structure of the transmission apparatus according to
the embodiment of the present invention;

Fig. 8 is a block diagram of an APC (ATM Processing Control) part of the control system

thereof shown in Fig. 7 and a peripheral part thereof; and

Fig. 9 is a block diagram of a detailed structure of the APC part of the transmission apparatus shown in Fig. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description will now be given of a management method related to the present invention in order to facilitate better understanding of the present invention.

Fig. 1 shows a management method related to the present invention. A system shown in Fig. 1 includes user's LANs, namely, Ethernet LANs 101 and 102, and a token ring LAN 103. The Ethernet LAN 101 is equipped with a site manager (network management system) 104 and a router 107. The Ethernet LAN 102 is equipped with a site manager 105 and a router 108. The token ring LAN 103 is equipped with a site manager 106 and a router 109. The routers 107 - 109 are connected by dedicated communication lines. In the network shown in Fig. 1, the site manager 105 functions as a master, and the site managers 104 and 106 respectively function as slaves. The site manager 105 collects management information concerning the site managers 104 and 106 therefrom, and integrally manages the users' networks.

The Ethernet LANs 101 and 102 are media (LAN nodes, also called islands) that are physically and logically different from the token ring LAN 103. These media are linked by the dedicated communication lines. When the network shown in Fig. 1 is expanded to further include a new user's network, it is required to include a site manager in the new network and link it to the other existing site managers by means of dedicated communication lines.

More specifically, as the number of ATM transmission spans linking a large number of CLAD units, the number of end points for making interfaces with the site managers physically increases. In addition, complexity of the network configuration (topology) of the ATM transmission gives impetus to increase in the number of CLAD units. Thus, the above-mentioned management method cannot flexibly cope with alteration of connections between the CLAD units. Further, the management method is capable of achieving only a limited application, in terms of the physical scale, to a large-scale WAN (Wide Area Network) expected to be achieved by the ATM transmission. In practice, the large-scale WAN which employs a virtual LAN (VLAN) or an emulated LAN (ELAN) can be achieved within only a very limited area in which customer premises equipment (CPE) can be configured (for example, within a single user area, a campus or an office block).

Also, in a case where a large number of users' networks is integrally managed, it is very difficult to determine who performs the integral management and who bears the cost thereof including the cost of installation of the dedicated communication lines.

The present invention is made taking into account the above-mentioned issues. More particularly, the present invention is directed to flexibly coping with a change of connections between the CLAD units and making it possible to achieve a large-scale WAN by using ATM transmission without any limitation in terms of the physical scale.

A description will now be given of an embodiment of the present invention. The embodiment of the present invention described below is an application to a transmission apparatus (network

equipment) that can be called an "ATM channel switch integrated type composite system with an option of STM channel crossconnect and CLAD accommodation". Hereinafter, such a system is simply referred to as a transmission apparatus.

A description will first be given of the concept of the whole network configuration by referring to Fig. 2. Fig. 2 is a diagram for illustrating an access to a customer network management agent process from a network management system of each user, and a protocol stack utilized in the above process. The customer network management agent process performs an integrated management of the user's networks on behalf of the respective user's network management systems. The integrated management can be given in charge to a third provider (for example, a management company of an ATM public telephone network). In this case, the entrusted management company can place the transmission apparatus within its own network. Alternatively, a specific one of the management companies which manage the respective user's networks may integrally manage the user's networks.

Referring to Fig. 2, the whole network includes a customer premises network (CPN) 1, a service provider network (SPN) 2, and a network management system (NMS) 3, which system is placed outside of the networks 1 and 2. The management system 3 manages the whole network (except for management of the inside of the user's networks). The networks 1 and 2, and the network management system 3 are equipped with respective network equipment (NE), and are mutually connected via ATM transmission paths.

The customer premises network 1 is connected to a customer network management system (site manager) 11 via a user LAN facility 15 by

A network element (NE) is placed into the service provider network 2, and is equipped with an OS/NE interface (local communication network (LCN)-LAN) 24. The network element (NE) is connected to an OS/NE interface 33 of the network management system 3 via an Ethernet 5. The network management system 3 has the original function of managing the whole network and is further equipped with a customer network management (CNM) agent process 31. The customer network management agent process 31 has a role of integrally managing the site managers of the networks 1 and 2. In the aforementioned related art, such a role is played by the master site manager. The customer network management agent process 31 controls a common management information base 32.

35 A reference number (1) shown in Fig. 2
denotes that an SNMP access which will be described
later is made on a dedicated/dialup line. In

connection with the SNMP access (1), there is depicted a protocol stack utilized between the customer network management agent process 31 and the customer network management system 11 of the network 1.

A reference number (2) shown in Fig. 2 denotes that an SNMP access is made by using the transmission medium 4 (which is an ATM/user network interface or a LAN). In connection with the SNMP access (2), there is illustrated a protocol stack utilized by the SNMP access made on the transmission medium 4. In this case, a customer SNMP management path is not terminated by an SNMP (Simple Network Management Protocol) agent process (the detail of which will be described later) placed in the network element NE, but is bypassed.

As will be described in detail later, management information concerning the networks associated with and collected by the user-side site managers 11 and 21, that is, an SNMP management packet (message) is sent to the customer network management agent process 31 of the network management system 3 by utilizing an idle area available in the band of the ATM transmission path established between the transmission apparatuses rather than a transmission path on the switch side. The customer network management agent process 31 integrally manages the network management information concerning the respective user's networks.

Fig. 3 is a diagram showing routing of the SNMP management packet. In Fig. 3, symbols NE1, NE2, NE3 and NE4 are respectively network elements, and are respectively equipped with routers and SNMP agent processes, which will be described later. The network element NE1 is a transmission apparatus having a gateway function, and the network elements

NE2 - NE4 are respectively remote transmission apparatuses. The network element NE1 is placed in, for example, a switch office, and is connected with a network management system (or OSS: Operation Support System) which manages the whole network. Information is transmitted and received on an SNMP protocol data unit (PDU) basis. The above-mentioned network management system is additionally provided with the aforementioned customer network management agent process. The network elements NE1 - NE4 are connected together via ATM transmission paths. Provisioning is carried out between the routers of the network elements NE1 - NE4. More particularly, provisioning is carried out by using a permanent virtual channel (PVC) used as an information exchange path via which the SNMP management packet is routed to the destination SNMP agent process. Permanent virtual channels as described above are respectively defined between the routers.

As to the network element NE3, a customer in-band type SNMP access, which will be described later, is illustrated as an example. The SNMP management message or package has the following two access formations. The first access formation allows an access via the ATM/user network interface/customer premises equipment (CPE) accommodating the CLAD unit. That is, the access is made via an ATM/UNI information 62 which will be described later. The second access formation allows an access in the case of the CLAD unit direct accommodation (that is, the access is made via a LAN interface 61 which will be described later). The SNMP management message of the user network is sent to the network therefrom by using one of the two access formations, and is delivered to the customer network management agent process 31 via the PCV.

Fig. 4 schematically shows an example of a

configuration of the transmission apparatus which functions as the network element NE according to the embodiment of the present invention. The LAN interface 61, which has briefly been described, accommodates a LAN which does not have the CLAD function. The ATM/user network interface (ATM/UNI) 62, which has briefly been described, accommodates a network having a CLAD function such as an ATM cell relay service. An ATM switch matrix part 63 determines a route. An apparatus controller 64 controls apparatus information in the transmission apparatus. The apparatus controller 64 has an SNMP interface (IP routing) 66, and communicates, on the SNMP protocol data unit basis, with the customer network management agent process (CNM Agent: see Fig. 2) provided outside of the transmission apparatus.

A description will now be given of the main operations and functions of parts indicated by reference numbers (0) - (4) shown in Fig. 4.

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20      (0):  Provisioning of a management-use PVC
      logical channel is performed in order to route the
      SNMP management message to the customer network
      management agent process for in-band customer SNMP
      traffic.

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25 (1): The value of VPI/VCI used by the
customer SNMP management message is prepared in the
customer premises equipment (which accommodates the
CLAD unit) in a case where the SNMP management
message is input from an ATM cell relay service
30 (that is, a case where the SNMP management message
is transmitted via the ATM/user network interface
62).

(2): An IP-VCC (Internet Protocol - Virtual Channel Connection) lookup entry is created in order to make it possible for the apparatus controller 64 to transmit a customer SNMP request message toward the customer network management agent

(3): Provisioning of management-use PVC information (concerning the IP and VCC) is performed in a case where the SNMP management message is input from a LAN (that is, a case where the message is transmitted via the LAN interface 61).

A description will be described of the detail of the above-mentioned transmission apparatus.

15 The transmission apparatus described below is capable of handling both STM (synchronous hierarchical multiplexing) transmission and ATM transmission.

30 The resource management in the ATM
transmission also uses, as collection/delivery paths
for in-apparatus information commonly owned in the
network, two data communication channels formed in
the overhead, with regard to information concerning
35 cell transmission and ATM switch (including
accounting information). The above resource
management is implemented by the TL1 management

subsystem and the CMISE subsystem.

In contrast, in the resource management of the CLAD unit itself accommodated in the transmission apparatus, particular cell transmission channels that are logically set on the payload carrier are used as user resources (a resource such as a LAN formation terminal and a router) and paths for collecting and delivering information concerning CLAD accommodating nodes, the paths being commonly owned in the network formed by the above nodes. The above resource management is implemented by a management process subset which is called an SNMP management subsystem and is capable of collecting node information.

The real substance of above three management subsystems is placed in a processor provided in the apparatus controller 64 which controls the apparatus information in the transmission apparatus, and commonly own a common management information base (CMIB: Common Management Information Base), which is controlled under the subsystems.

As an application of the present invention, a description will be given of the structure of resource management paths used for a CLAD unit resource defined as the in-band type SNMP access and a user resource (such as a LAN formation terminal or a router). The term "in-band type" of the in-band type SNMP access is used as a meaning that the resource information provision paths are assigned to particular cell transmission channels logically set on the payload carrier and the ATM transmission is performed together with user data (cells).

The transmission apparatus provides two SNMP interfaces. One of the two SNMP interfaces is an out-band (an external channel carrier) interface via an SNMP management port. The above out-band

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interface is, for example, the Ethernet shown in Fig. 2. The other SNMP interface is an in-band interface which uses the service function part of the present transmission apparatus, such as an ATM/user network interface or an interface with a LAN. The ATM/UNI transmission medium 4 shown in Fig. 2 is an in-band interface. The term "in-band" is used as a meaning of a carrier subset provided by the particular cell transmission channel logically set on the payload carrier, as has been described previously.

The resource management of the CLAD units are configured so as to cope with the following two cases.

(1) Case 1 (a case via ATM/UNI interface 62):

The present transmission apparatus does not directly accommodate the CLAD unit. However, there is a case where a cell relay service provided by the present transmission apparatus brings the CLAD unit function by means of the CLAD unit provided in the customer premises equipment (CPE) located in a position opposite to the present transmission apparatus. In such a case, the SNMP management subsystem of the present transmission apparatus puts resource management information concerning the CLAD unit up on the customer network management agent process (CNM Agent) located outside. Thus, an exchange of the resource management information concerning the CLAD unit between the customer network management agent process and the site manager located on the side of the ATM cell relay service network is bypassed.

(2) Case 2 (a case via the LAN interface 61):

When the present transmission apparatus accommodates the CLAD unit, the SNMP management subsystem of the present transmission apparatus

provides resource management information concerning the CLAD unit.

In order to cope with the above-mentioned two cases, it is required that the out-band access and the in-band access cooperate with each other. Such a cooperation will be described with reference to Fig. 2.

The present transmission apparatus is equipped with an OS/NE (Operation System/Network Element) for the out-band access (see the OS/NE interface 24 shown in Fig. 2). Generally, the OS/NE interface is a LAN (Ethernet) or X.25. However, in the present embodiment of the invention, only a LAN port is presented as an interface with the out-band access because the LAN underlies the physical layer of the SNMP-system application (see Ethernet 1 shown in Fig. 2). The customer network management agent process 31 connected to the LAN port is the object of the out-band access. However, the customer network management agent process 31 is generally placed in an agent formation as a part of the network management system 3 of the user.

With regard to the in-band access, the site manager provided under the following condition is the object of the in-band access. That is, the site manager is connected to the LAN network extending to the user side via the CLAD unit in the customer premises equipment located in a position opposite to the present transmission apparatus by the cell relay service using the ATM transmission (see the LAN interface 12 shown in Fig. 2) or the CLAD unit which is directly accommodated in the present transmission apparatus (see the ATM/UNI interfaces 13 and 23 shown in Fig. 2).

In this regard, the in-band type SNMP access is implemented by forming the information path of the customer network management agent

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Datagram Protocol/Internet Protocol).

5 The SNMP agent process function as shown
in Fig. 3 handles the SNMP management information
and prepares SNMP information exchange requests and
a response process for these requests. More
particularly, the SNMP agent process that has the
common management information base (CMIB) under the
control accesses the common management information
base by using an appropriate application interface
10 when the SNMP management message comes to the
present transmission apparatus via the SNMP
management port irrespective of whether the message
is based on the in-band access or the out-band
access. Then, the SNMP agent process gets
15 information from an abstraction function unit placed
in the common management information base and sets
(requests) an operation as a logical window of a
detection system (such as condition, PM, or alarm)
or an operation system (control or provisioning)
20 which cooperates with the physical substance of the
present transmission apparatus.

In addition, the SNMP agent process also
supports an autonomous report process. More
particularly, the SNMP agent process transfers
25 information concerning a predetermined failure in
hardware or software to all SNMP management
providers in the network by a method called an SNMP
trap, so that internal information in the respective
SNMP management providers can be updated.

30 The in-band access system operation
requires the following functions which serve as
hands and feet for exchanging information by the
above-mentioned SNMP management subsystems.

IP routing function

35 An IP routing function is implemented on
the SNMP management subsystems, and routes, from the
OS/NE interface, all SNMP management packets sent by

Information path setting function

5 a logical channel for a cell transmission in a permanent connection formation in the ATM switch matrix part 63 of the present transmission apparatus. The information path setting function sets an information exchange path between a user-system
10 facility interface part (LAN interface 61) with accommodation of the CLAD unit (which is in the local or the present transmission apparatus, or a remote apparatus other than the present transmission apparatus) or the cell relay service part without
15 accommodation of the CLAD unit and the IP routing function part of the SNMP management subsystem in the apparatus controller 64.

resource management of the CLAD unit based on the
20 above two functions with regard to the
aforementioned two cases (Case 1 and Case 2). More
particularly, the following description is directed
to a scenario as to how the IP routing function
operates.

25 (1) Case 1:

Case 1 is applied to a service interface called ATM/user network interface (ATM/UNI). The IP routing function of the customer premises equipment (CPE) inquires of the customer network management agent process 31 which VPI/VCI (Virtual Path Identifier/Virtual Channel Identifier) should be used to establish the SNMP management information path, that is, which particular cell transmission channel logically set on the payload carrier should be used. Then, the customer premises equipment (CPE) registers the VPI/VCI determined by the agent process 31 in its own local routing information

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(2) Case 2:

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Fig. 5 is a block diagram illustrating the function of the present transmission apparatus. Fig. 6 is a diagram of a hardware structure of the

present transmission apparatus. Fig. 7 is a block diagram of a control system of the present transmission apparatus, and Fig. 8 is a block diagram of an APC (ATM Processing Control) part of the control system thereof and a peripheral part thereof. Fig. 9 is a block diagram of a detailed structure of the APC part of the present transmission apparatus.

First, a description will be given of the whole operation and function of the present transmission apparatus.

Referring to Fig. 5, the SNMP protocol data unit (PDU) of the site manager interfaced by the ATM/UNI (via CPE) or LAN (direct accommodation) is coupled to a service complex of the present transmission apparatus shown in Fig. 5 in such a manner that an ATM/UNI channel card is coupled in the ATM cell formation and a LAN card is coupled in the packet formation. These cards are those among a group of cards called "trib" (see Fig. 6). The SNMP protocol data unit thus coupled to the service complex interfaced by the ATM/UNI channel card is sent to a switching complex shown in Fig. 5 as it stands (without missing the ATM cell formation). The SNMP protocol data interfaced by the LAN, which is arranged in the package formation, is mapped, by segmentation, on the ATM cell(s) by the CLAD unit accommodated in the transmission apparatus. The ATM cell thus produced is sent to the switching complex.

The SNMP protocol data unit arranged in the ATM cell formation is applied to the switching complex and is taken in an STS-SF (Synchronous Transport Signal Switch Fabric) card shown in Fig. 6. Then, the SNMP protocol data unit is transferred to an ATM-SF card having ATM visibility shown in Fig. 6. The ATM-SF card compares the VPI/VCI values corresponding to the IP address with which the SNMP

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order process, and is utilized as a database configuration information element for performing the LAN-system resource management and network management.

5 The database thus built up can be referred to by the external customer network management agent process by coupling the LCN port on the DCC by means of the NECPU-DCC-LCN system path.

10 Referring to Fig. 5, the whole function configuration of the present transmission apparatus is made up of the following five complexes. Each of the five complexes has the following functions.

Transport complex

- LINE terminating function
- 15 -SONET (OC-n)/SDH transport function

Service complex

- TRIB terminating function
- STM/ATM/LAN/FR accommodating function

where FR is an abbreviation of the frame relay

20 Switching complex

- LINE/TRIB traffic (data unit and frame timing) connecting function on the STS/VT/ATM cell bases

- STS/VT-TSI function by crossconnect
- 25 -VC/VP-ATM exchanging function

Synchronization complex

- System timing synchronizing function by determination and distribution of in-apparatus timing

30 Management complex

- Severance by in-apparatus information collection and exchange and as carrier quality checking and performance evaluating function
- Apparatus operation executing (including
- 35 download and backup) function
- Network management (TL1, FTAM, CMLSE, SNMP, FTP) interface function.

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Switching complex

-none

Synchronization complex

-none

5 Management complex

-OW/OW-MDM where OW denotes order wire,
and MDM denotes modem.

The packages/units have the following
10 shared functions.

(1) LINE

This provides an optical carrier a node-
to-node transport up to OC-3, OC-12 and OC-48. The
STS or STSc is used for the transmission payload,
15 and SPE and OH (overhead) are transmitted and
received. As to SPE, a complex connection with STS-
SF is made. As to OH, a complex connection with OHD
on APS/HUB is made.

(2) TRIB

20 The packages/units TRIB (trib) are channel
units which terminate electrical carriers (such as
DS1, DS3, FR, LAN-ELC), channel units which
terminate optical carriers (OC-3, OC-12, LAN-OPT),
and router units (SPC) that perform LAN routing
25 (such as a VLAN system and an IP system). The STS-
SF and OHD are complex-connected. The optical-
system units are functionally and physically
diversion of LINE except for the LAN-OPT. In the
electrical-system units including the LAN-OPT, a
30 TDM-system (channel) bearer, an ATM-system (cell)
bearer, an IP-system (packet) bearer, and a data-
system (an encapsulated packet) bearer are mapped and
demapped between the STSc or STS and STS/VT.
Particularly, the units which handle packets
35 (including a decapsulated packet) or an in-channel bit
stream (CE: circuit emulation, TDM/ATM conversion)
requested to be assembled in the cell formation has

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the function of the CLAD (which cells and decells a packet).

(3) STS-SF

Traffic of STSc or STS which is complex-
5 connected with LINE, TRIB is handled on an STS basis.
The crossconnection of STS/STSc is made by a static
allocation by the setting of the operation. For the
process on the VT basis or cell basis, there is
provided a complex connection with VT-SF and ATM-SF.

10 (4) VT-SF

Traffic in complex-connection with STS-SF
is handled on the VT basis. The crossconnection of
VT is made by the static allocation by the setting
of the operation.

15 (5) ATM-SF, APC

Traffic in complex-connection with STS-SF
is handled on the cell basis. The crossconnections
of the VC/VP of cells gathered on a use unit basis
are subjected, for both the user/network interface
20 (UNI) and the network/network interface (NNI), to a
given procedure defined between adjacent nodes and
is autonomously made between exchange intelligence
parts. The execution of the procedure depends on
exchange of related information between adjacent
25 nodes and the management of the internal states of
the respective nodes. The above function is handled
by the APC. ATM-SF provides physical and logical
interfaces for the above information exchange, and
makes the crossconnections indicated by the
30 procedure. After the crossconnections are made,
traffic is subjected to the quality check and
performance evaluation. Then, it is determined
whether the values actually obtained by the quality
check and performance evaluation match the logical
35 values regarding the quality and performance defined
on the procedure. If there is a mismatch, a given
action is performed. The autonomous operation on

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the crossconnections based on the procedure between the exchange intelligence parts is recorded as an exchange execution unit. There is also provided with means for controlling the use of channels in a quantitative fashion on the basis of whether an exchange connection fails or not.

The autonomous crossconnections are categorized into any of the following three types, PVC, software PVC and SVC, which depend on the subject which issues a request. The PVC and software PVC execute the static allocation. There is a PVC which indicates a connection route in a fully manual fashion, and a software PVC in which predetermined route information is input and set and connection route information is determined with a help of a PNNI (Private Network to Network Interface) software. The SVC executes a dynamic allocation. Also, as an independent control algorithm, the ATM-SF and APC perform an APS (Automatic Protection Switching) control for execution of ATM path protection (VP servivility) and manages the execution.

(6) SNYC

This handles a system timing synchronization due to determination and distribution of the in-apparatus timing.

(7) NECPU

This maintains the in-apparatus management information base. This serves as a brain which supplies, by messages, associated hardware parts with concrete instructions based on logical actions extended in the virtual field by an external operation so that the logical actions are changed to physical and tangible actions. More particularly, the NECPU executes surveillance, quality check and performance evaluation due to in-apparatus information collection and exchange and executes

operations on the transmission apparatus (including download and backup).

(8) DCC

5 This has a physical path for information exchange with the external operation and a logical channel equipped with a connection procedure on a layer structure (protocol) basis. The DCC cooperates with the NECPU to form the network management (TL1, FTAM, CMISE, SNMP, FTP) interfaces.

10 (9) APS/HUB

15 This functions as an actuator, which directly contacts packages/units forming hardware parts which are in charge of transport, service, switching, synchronization and so on, and interprets operation messages issued by the NECPU or the like in order to convert the operation messages into the physical and tangible actions. The APS/HUB also functions as a sensor which collects and interprets physical and tangible states and phenomena of the packages/units, and sends resultant operation messages to the NECPU. Further, as an independent control algorithm, the APS/HUB is in charge of APS control and management of execution. Examples of the APS control are path protection (UPSR, STS-BLSR, 20 VT-BLSR), line protection (optical units), apparatus protection (electrical units, and units in switching and synchronization complexes).

(10) OW, MDM

30 This has an order wire function and a modem unction which extends a local craft to a VF band for remote crafting.

The present invention is not limited to the specifically disclosed embodiments, and variations and modifications may be made without 35 departing from the scope of the present invention.